

DYNAMIC LANDUNITS IN CLM

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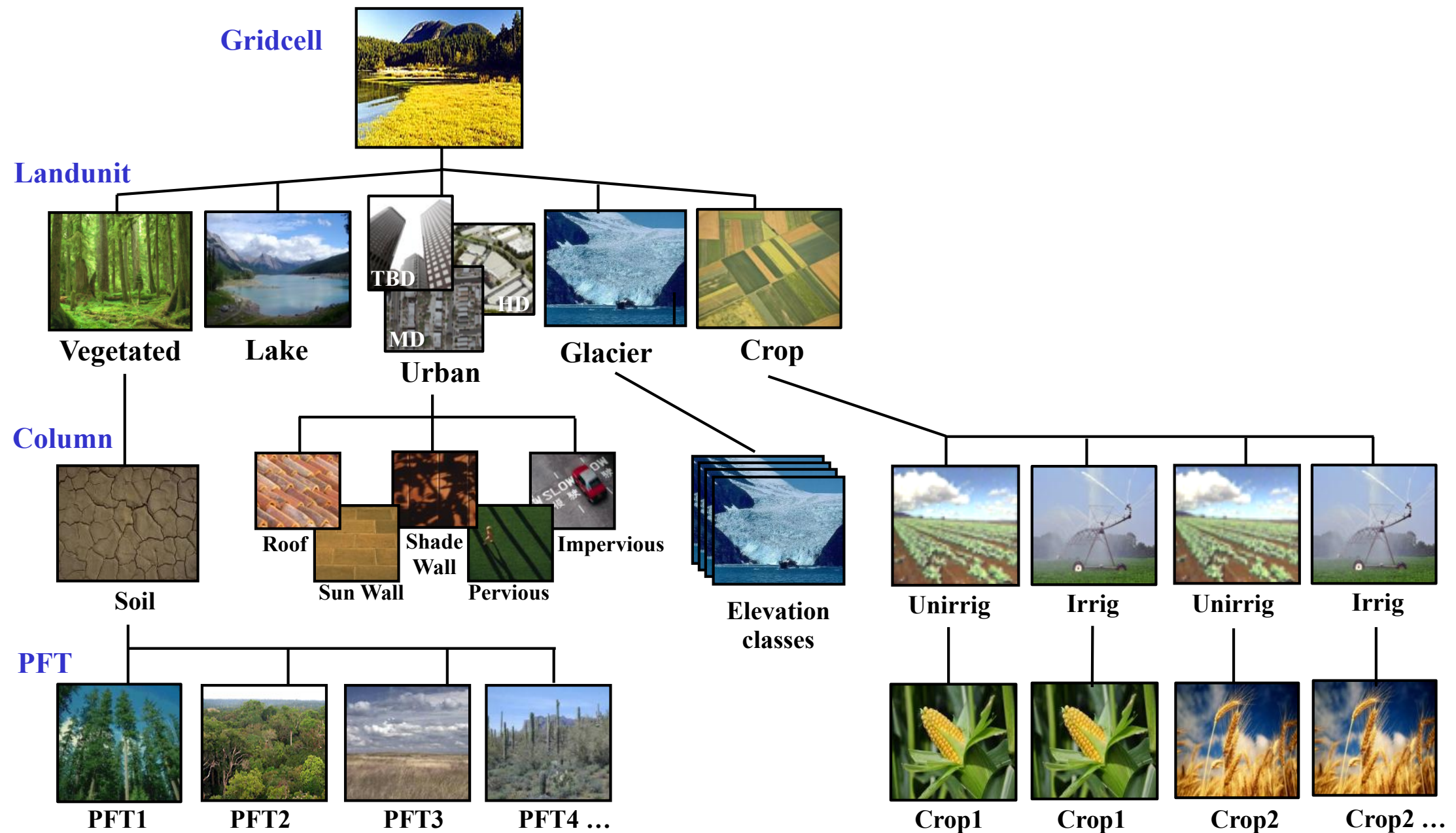
With contributions from:

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Dave Lawrence (NCAR), Bill Lipscomb (LANL), Zack Subin (LBL), and Mariana Vertenstein (NCAR)

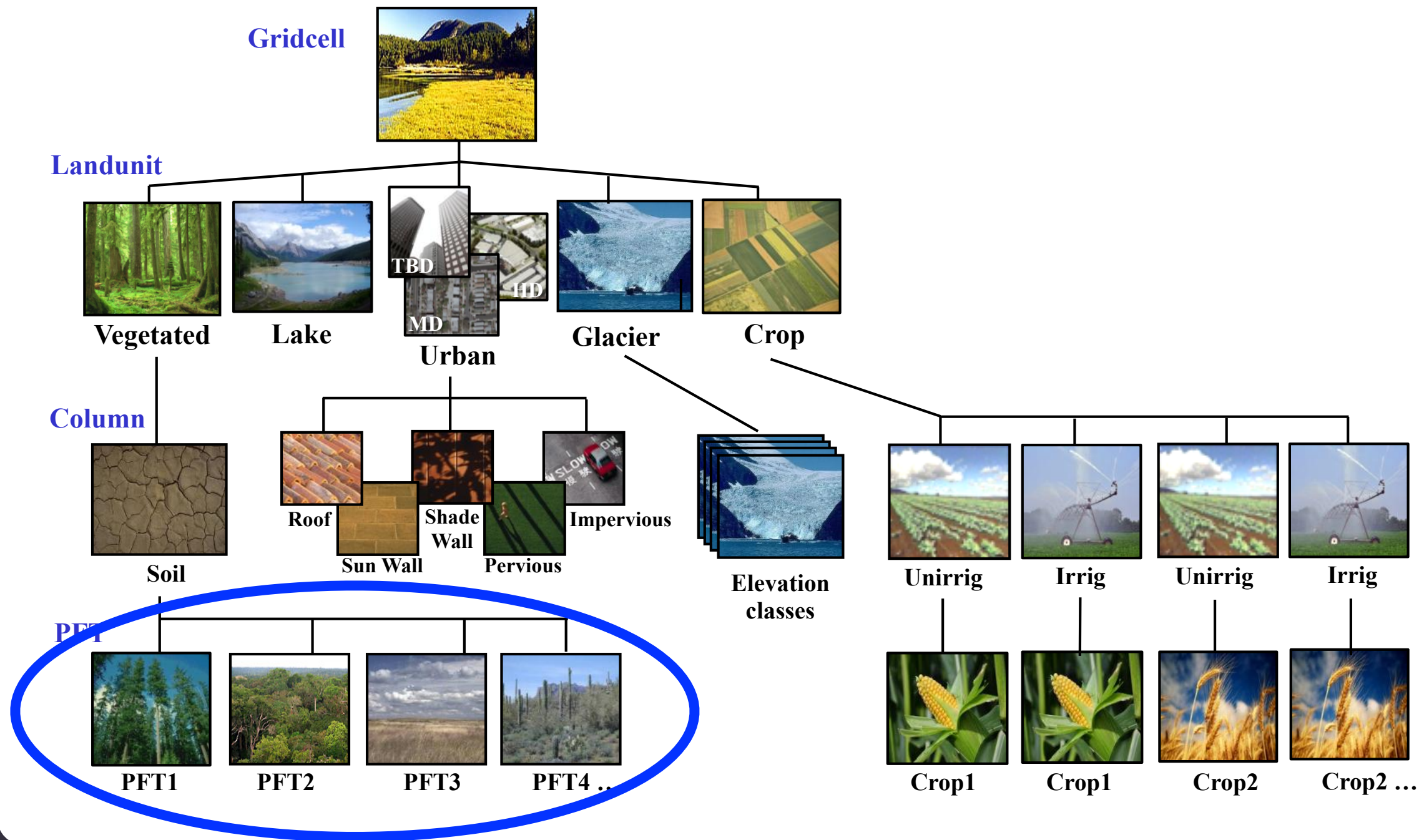
and additional guidance from:

Alan Di Vittorio (LBL), Andy Jones (LBL), Sam Levis (NCAR), Keith Oleson (NCAR),
Bette Otto-Bliesner (NCAR), and Bill Riley (LBL)

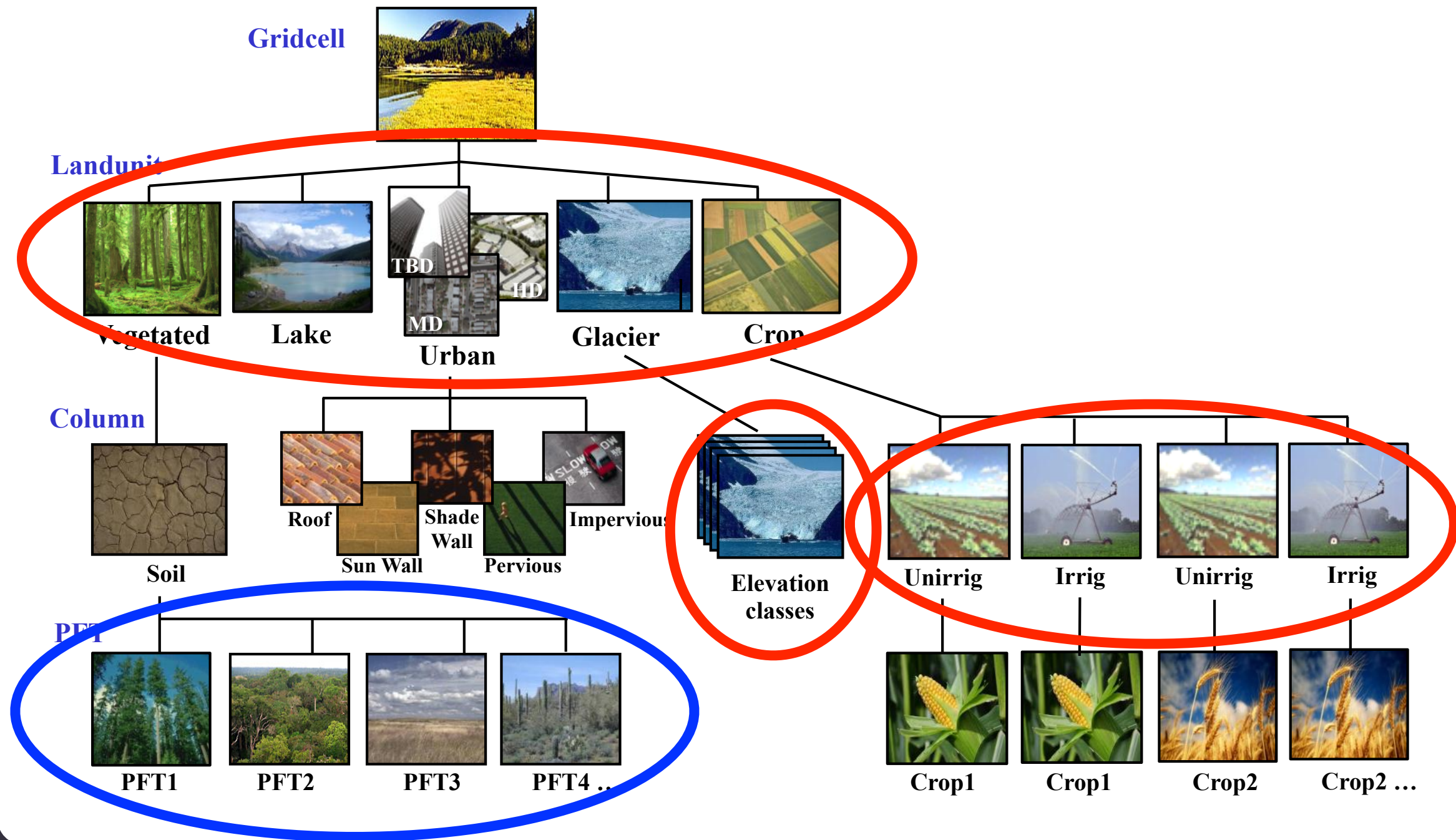
Intro: CLM Gridcell Organization



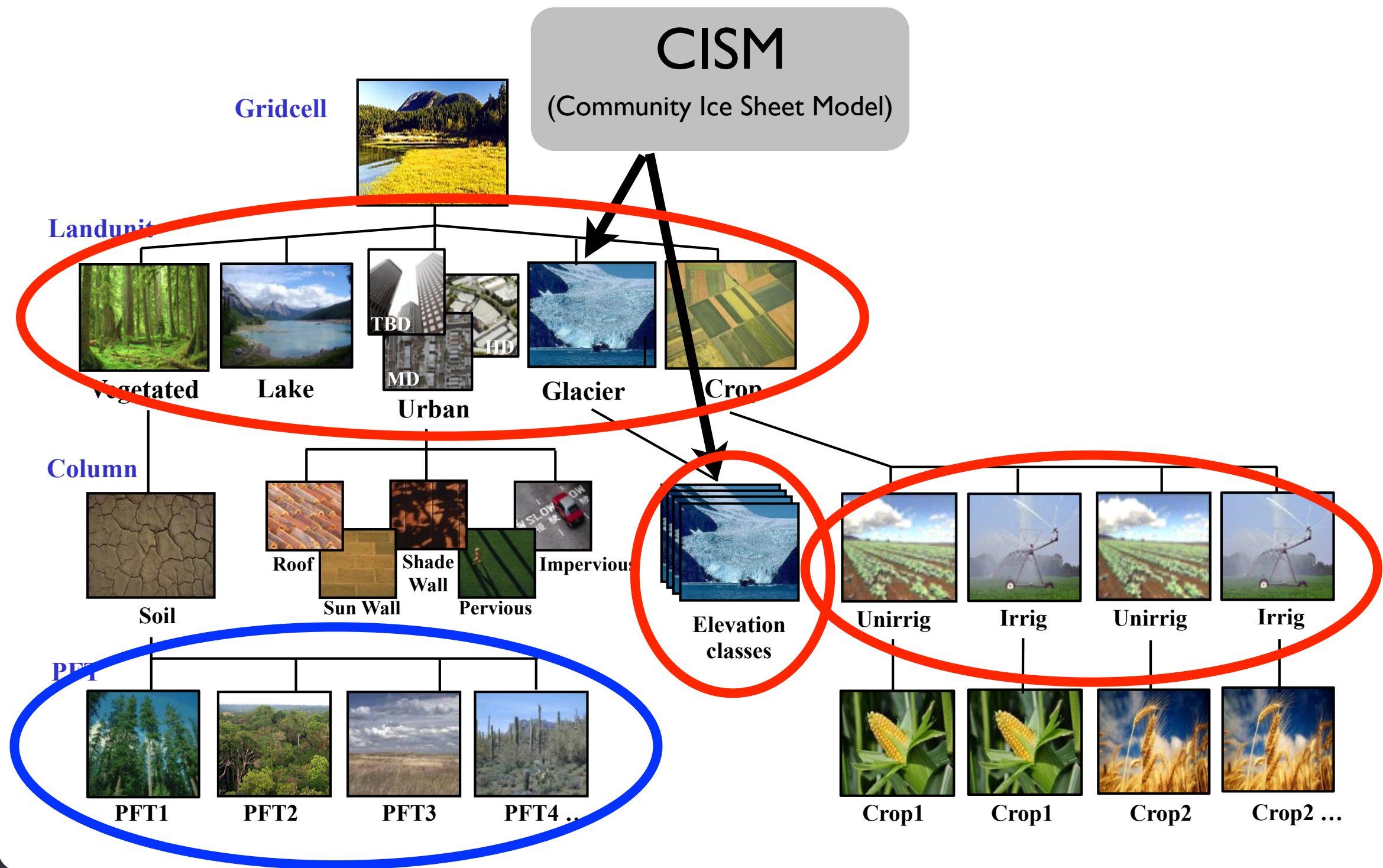
Intro: CLM Gridcell Organization



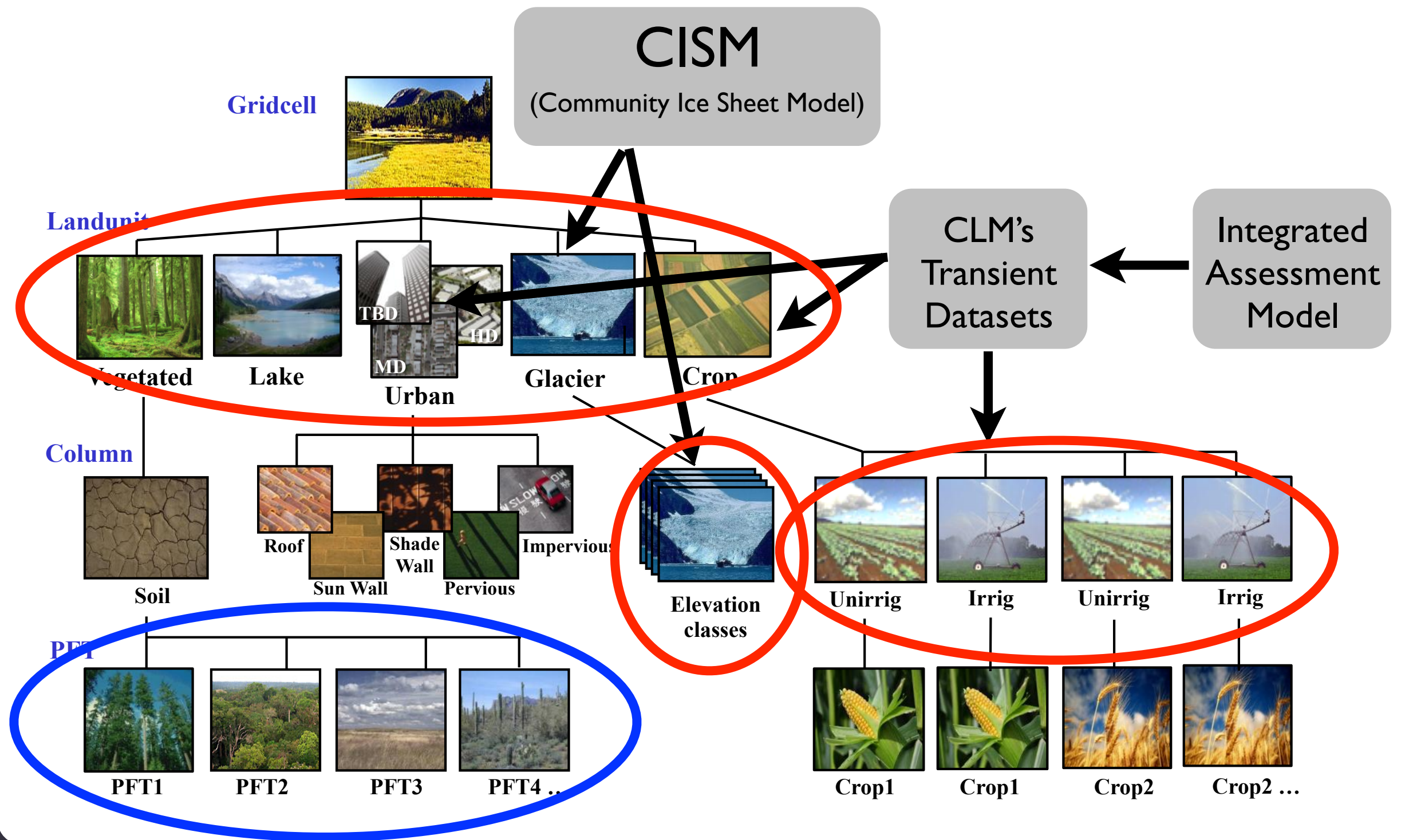
Intro: CLM Gridcell Organization



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Near-term Science Targets

Glacier dynamics

- Future stability and potential for recovery of the Greenland Ice Sheet, considering feedbacks
- Transient simulations of the Last Interglacial
- Transient simulations of deglaciation following the Last Glacial Maximum

Crop dynamics

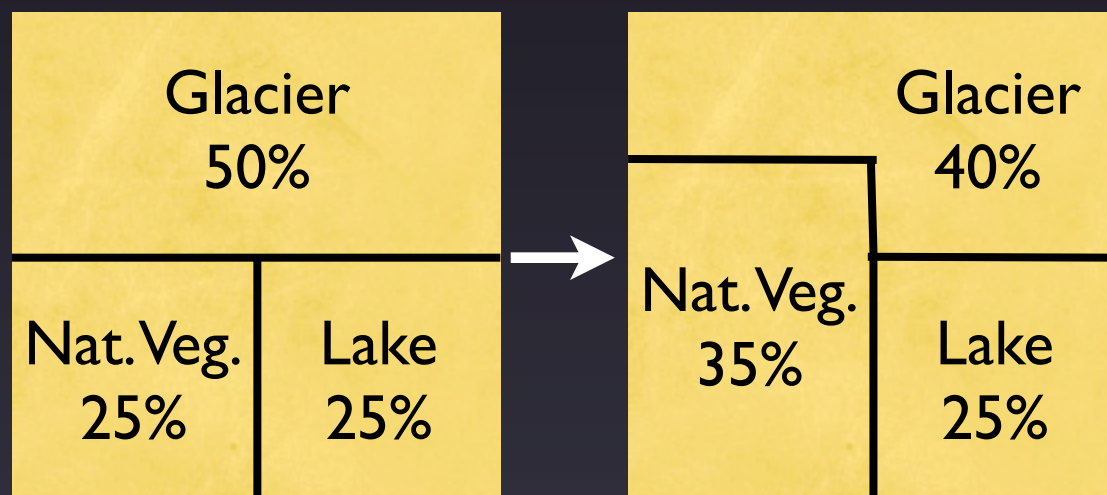
- Transient runs with managed crops (Levis et al.) – finally!
- Coupling CESM to the iESM integrated assessment model

Scientific Challenges

Given areas of SOME landunits,
how should we set areas of other landunits?

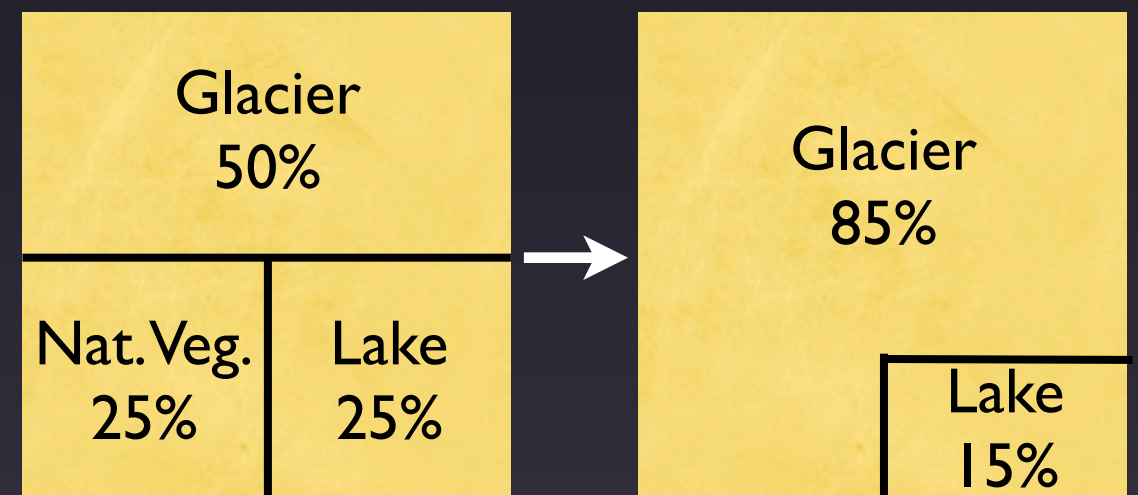
Shrinking glacier / crop

Natural vegetation takes over



Growing glacier / crop

Priorities for decrease,
starting with natural vegetation

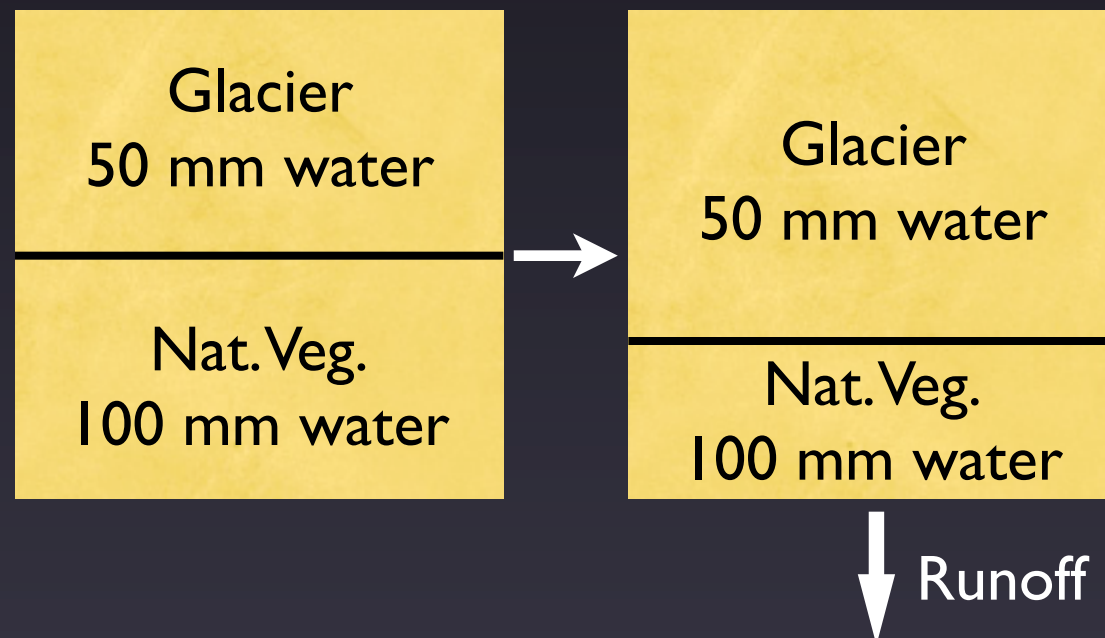


Scientific Challenges

How should we conserve water & energy?

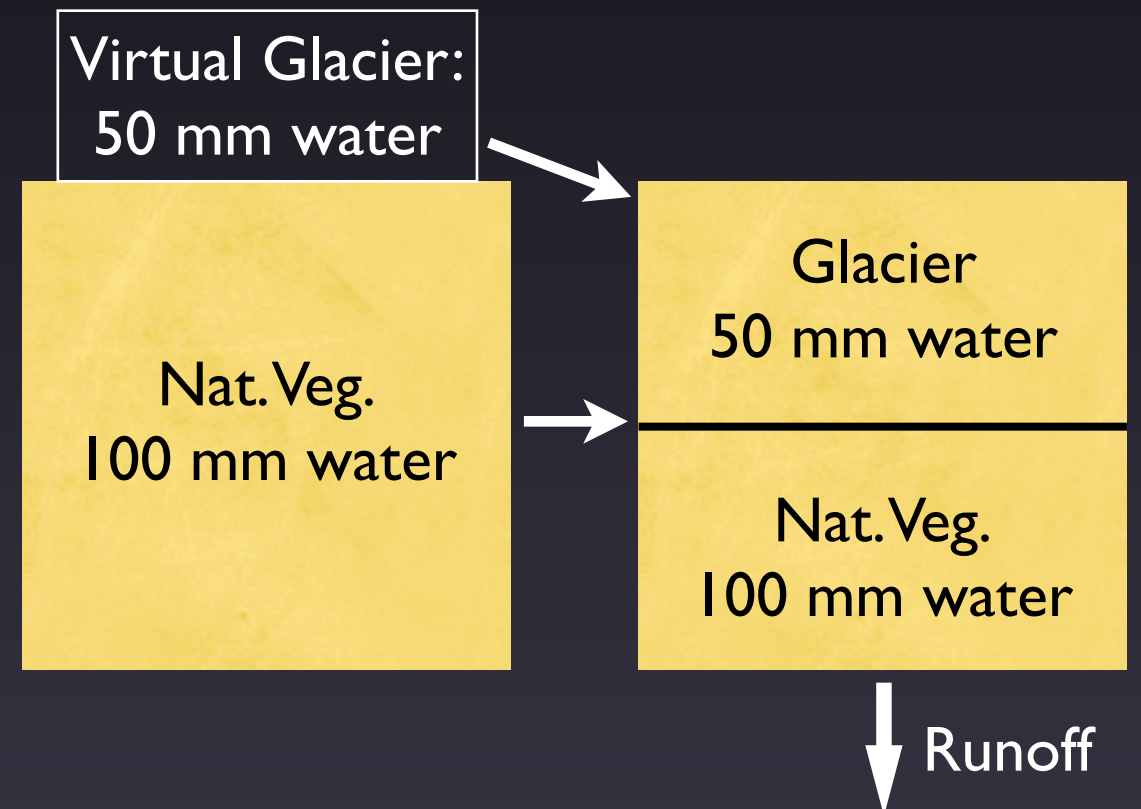
Changing areas of
existing columns

No state adjustments;
instead, introduce adjustment fluxes



Initialization

Use state from spun-up 'virtual'
column, followed by adjustment fluxes

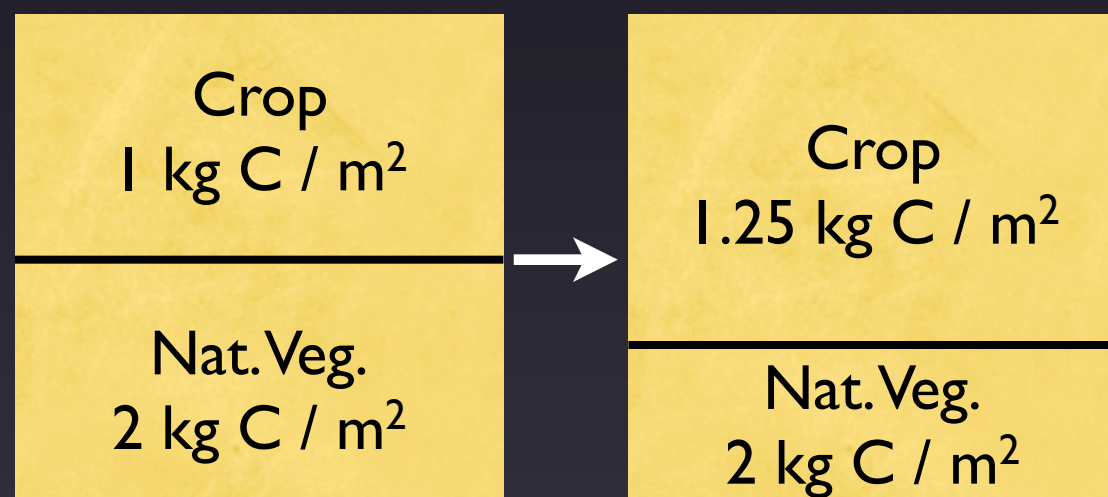


Scientific Challenges

How should we conserve carbon & nitrogen?

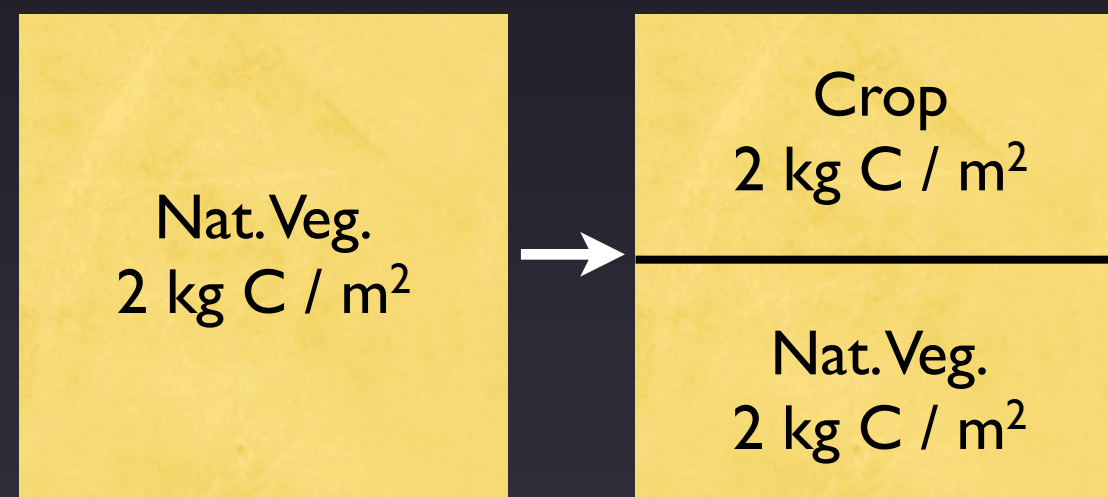
Changing areas of
existing columns

Weighted averages of
shrinking & growing areas
(rigorous conservation)



Initialization

Take state from shrinking areas
(this is just the edge case
of the first scenario)



Side-note: Unit Testing

Unit testing framework recently added to CESM

- ▶ See Sean Santos's SEWVG talk, Thurs at 11:15
- ▶ `$CCSMROOT/tools/unit_testing`

```
@Test
subroutine test_standard_points()
  ! Tests multiple points, not edge cases

  @assertEqual([26125.331269192659_r8, 33030.159082987258_r8], &
    daylength([-1.4_r8, -1.3_r8], 0.1_r8), tolerance=tol)
end subroutine test_standard_points
```

```
@Test
subroutine test_north_pole()
  ! Tests north pole point, including rounding error

  @assertEqual(86400._r8, &
    daylength(SHR_CONST_PI/2.0_r8, 0.1_r8), tolerance=tol)
  @assertEqual(86400._r8, &
    daylength(SHR_CONST_PI/1.999999999999999_r8, 0.1_r8),
    tolerance=tol)
end subroutine test_north_pole
```

CLM unit tests largely target dynamic landunit code

- ▶ Importance: some of this code will rarely be executed

Dynamic Landunits: Demonstration

Fast deglaciation experiment: 100% to 0% in 5 years

Year 1

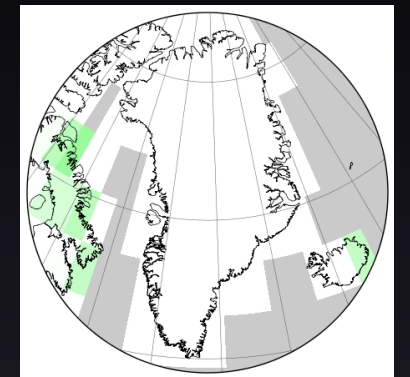
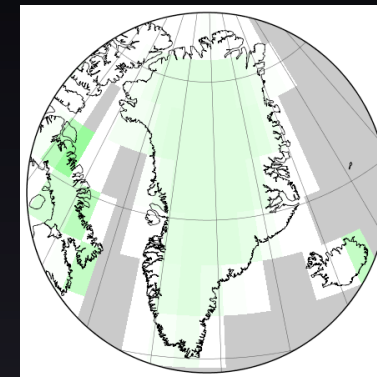
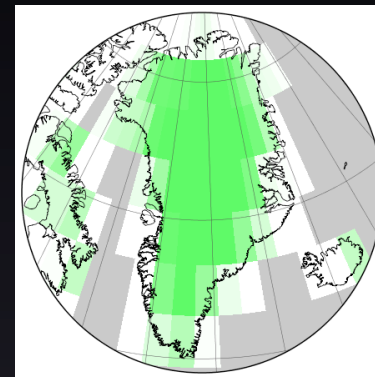
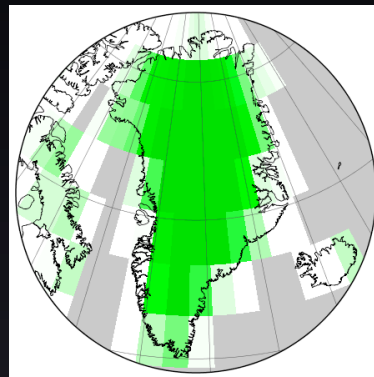
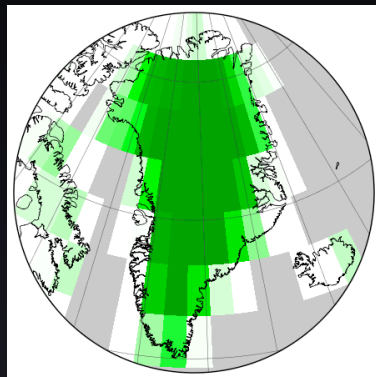
Year 2

Year 3

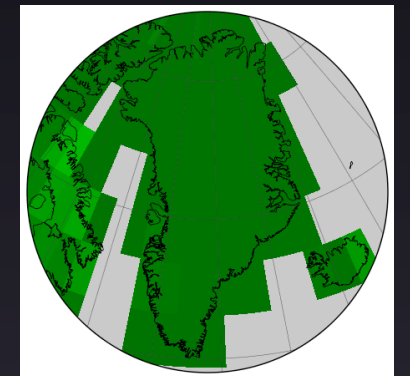
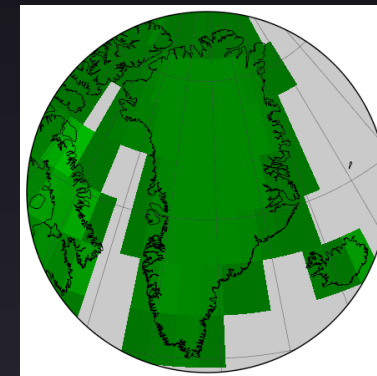
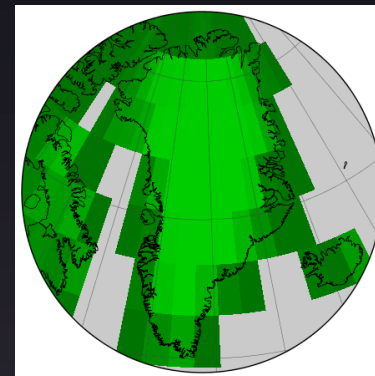
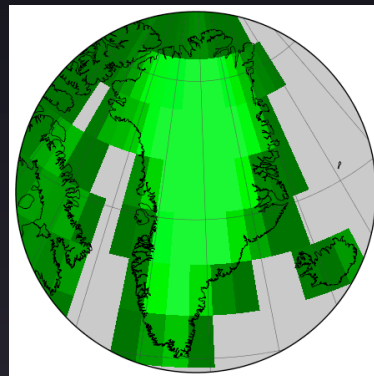
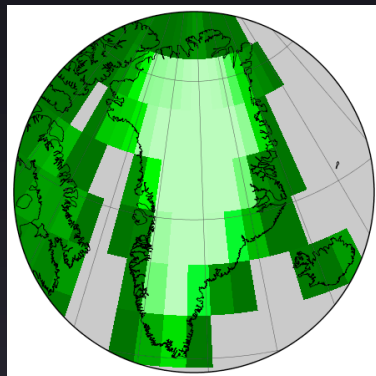
Year 4

Year 5

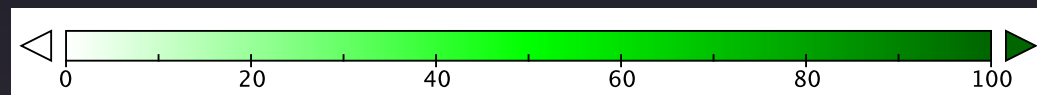
Glacier
Area



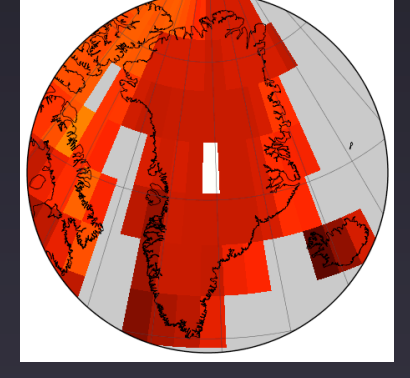
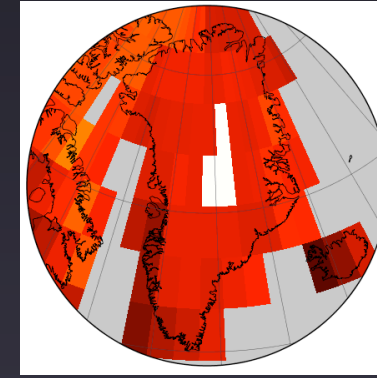
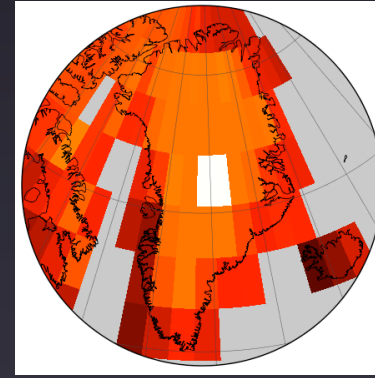
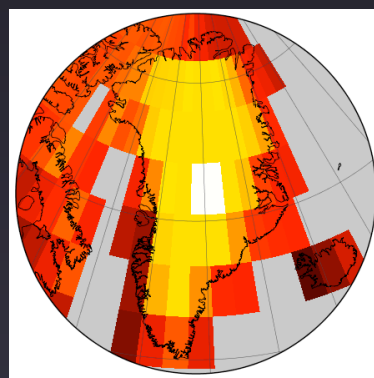
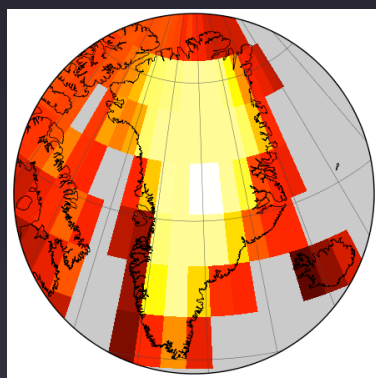
Natural
Veg.
Area



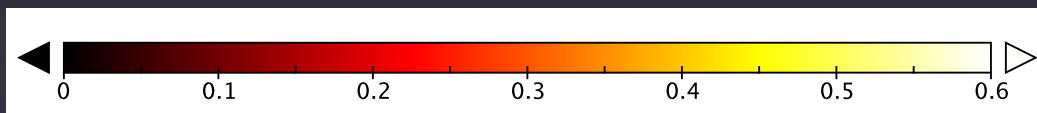
% of grid cell



No-snow
Albedo



Albedo (fraction)



What's Left?

- Wrap up transient crops
- Water & energy conservation
 - ▶ Conservation within CLM: basic code in place. Needs scientific review and some tweaking.
 - ▶ Mapping between CLM and CISM needs to be rewritten
- Carbon & nitrogen conservation
 - ▶ Prototype code written; need to plug into CLM.

Memory Reordering for Dynamic Landunits

Old

Grid cell	1	1	1	2	2	2
Landunit type	1	2	3	1	2	3

New

Grid cell	1	2	1	2	1	2
Landunit type	1	1	2	2	3	3

24% performance improvement